NOTE ON THE FLORA AND SNOW COVER DISTRIBUTIONS AFFECTING THE APPEARANCE OF NORTHEASTERN UNITED STATES AS PHOTOGRAPHED BY TIROS SATELLITES

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Distinguishing clouds from light surface backgrounds such as sand or snow in satellite photographs is an important but often difficult task. It is the purpose of this note to present an example in which snow was mistaken for clouds over the Adirondack region of New York and to provide some guidelines for more accurate interpretation of ambiguous cases.

Figure 1 is a nephanalysis chart for 1533 GMT, December 7, 1964, showing the northeastern United States with cloudiness surrounding the Adirondacks. Figure 2 shows the picture from which the chart was prepared. In reality most of the area around the Adirondacks was clear.

In the area of interest, the Laurentians, Adirondacks, Green, and White Mountains in all seasons of the year usually appear relatively dark while the surrounding valleys are lighter in tone. Of these mountainous areas, the Adirondacks and Laurentians are darker than the others. These observations disagree with those of Cronin [3] who mapped the tonal shades of the United States and southern Canada from TIROS photography for the period from February to April. He showed the Laurentians, Adirondacks, and Green Mountains as light in tone. The Adirondacks were described as "nothing particularly distinctive" although he added, ". . . since the tree cover is principally coniferous, the crowns may retain snow for a while after a fall." Later, Bird and Morrison [1], also utilizing TIROS photography, noted that the Laurentians, when snow covered, appeared grey, while the nearby valleys which were free of snow were dark. They documented this further (Morrison and Bird [4]) by presenting a case of change from light to dark tone as a snow cover melted in the St. Lawrence Valley over a 2-week period.

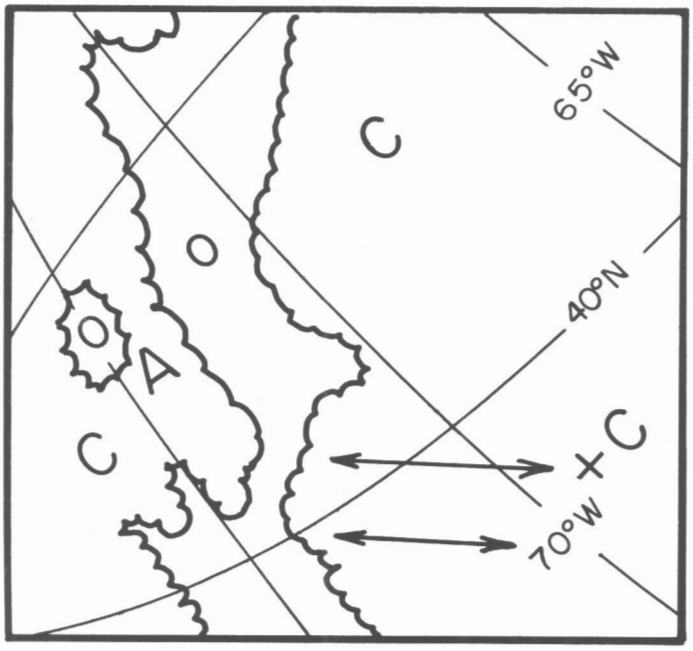

FIGURE 1.—Nephanalysis chart for 1533 GMT, December 7, 1964. C>80 percent, MCO=50–80 percent, MOP=20–50 percent, and O<20 percent cloudiness. The cloud-covered area A was actually clear.

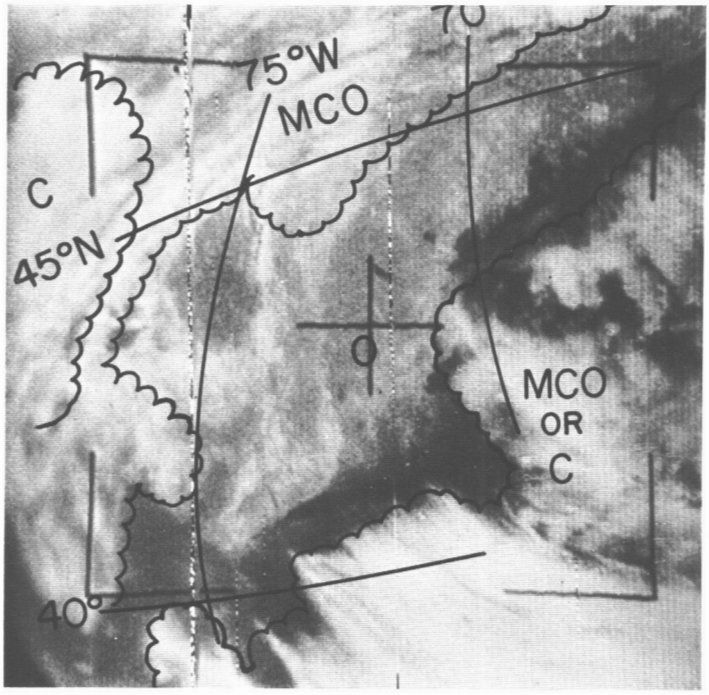

FIGURE 2.—Picture from which the chart of figure 1 was prepared. TIROS VII, orbital pass 7943, C2 T32. A correct nephanalysis, based partly on surface observations, has been added.

Further investigation of the area was prompted when the author obtained aerial photography of the Green and Adirondack Mountains on April 2, 1964. At that time a snow cover remained over the central and highland portions of each mountainous area. Inspection of this photography revealed more coniferous and continuous forest over the Adirondacks than over the Green Mountains. Open fields within the Adirondacks are uncommon, while they are common and widely distributed even on hillsides in Vermont. This presumably is related to the fact that the Adirondack Mountains and foothills are precisely contained in a State Park, whereas much of the Green Mountain area is privately owned with a consequent difference in land management regimes. Outside the Adirondacks, open fields are nearly continuous. The differences in the type of forest and distribution of open fields account for an integrated darker tone over the Adirondacks as compared to the Green Mountains. Since the Laurentians are also predominantly coniferous in forest cover with few open areas, they are equally dark in appearance. The White Mountain area of New Hampshire has a distribution of flora similar to that of the Green Mountains, and its tone appears the same in the satellite pictures.

These observations coupled with the satellite pictures of the area, show that in general the darkest tones characterize coniferous forest, and the lightest tones indicate open farmland. The tone of deciduous forest is between the two, and combinations of forest and farmland, when small areas of each are mixed, yield integrated intermediate tones.

However, there are variations to these generalities which are summarized below by season:

Summer: At this time, the valleys surrounding the Adirondacks are distinctly lighter than the mountains. The Adirondacks are the same or slightly darker than the Green Mountains. The picture in figure 3 illustrates these characteristics.

Fall: Tonal range between the mountains and the valleys reaches a minimum, but a distinction can be noted in the good photography. The decrease in contrast from summertime is caused by changes in the spectrum of reflected light. Even in the Adirondacks, there is a large percentage of deciduous forest. These trees change from summer greens to shades of brown, yellow, and red, while the farmland shifts from light green to brown. Since the satellite system is most responsive in the range of yellow and orange, the tone of the forest is shifted more toward white than is that of the farmland. The result is a decrease in contrast between the two.

Winter: A snow cover of about 1 in. will whiten the Champlain and St. Lawrence valleys considerably. Amounts of about 4 in. or more will increase the reflectance

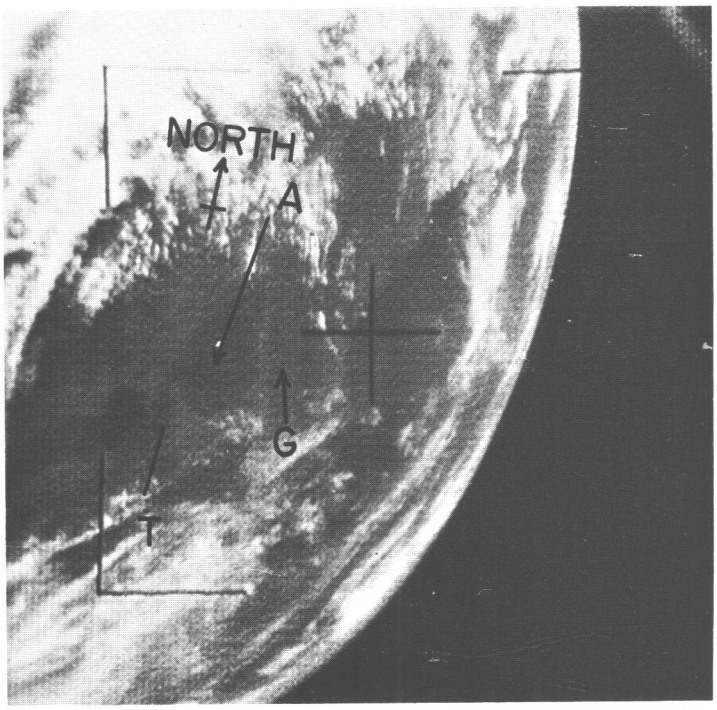

FIGURE 3.—Summer. Adirondacks (A), Tug Hill Plateau (T), and Green Mountains (G). See figure 4 for geographical grid. TIROS VIII, August 7, 1964, 1937 GMT, orbital pass 3340, C1 D2.

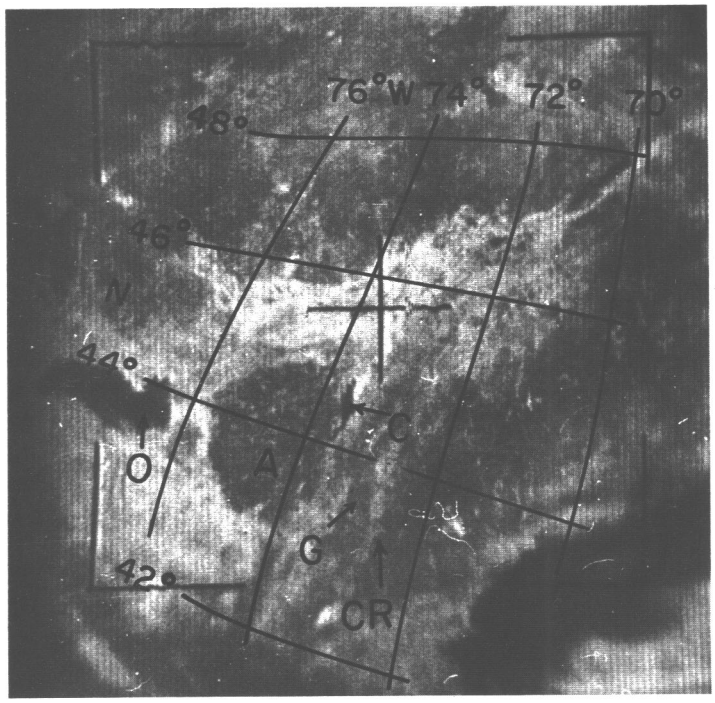

FIGURE 4.—Winter. Snow cover is present over the entire area of interest. Amounts in the lowlands surrounding the Adirondacks range from 1 to 6 in.; 10 to 30 in. lie on the ground over the dark, mountainous areas. Open water is visible in Lakes Champlain (C), Ontario (O), and the lower St. Lawrence River. Connecticut River Valley is at CR. 1508 GMT, February 9, 1964. TIROS VII, orbital pass 3478, C1 T28.

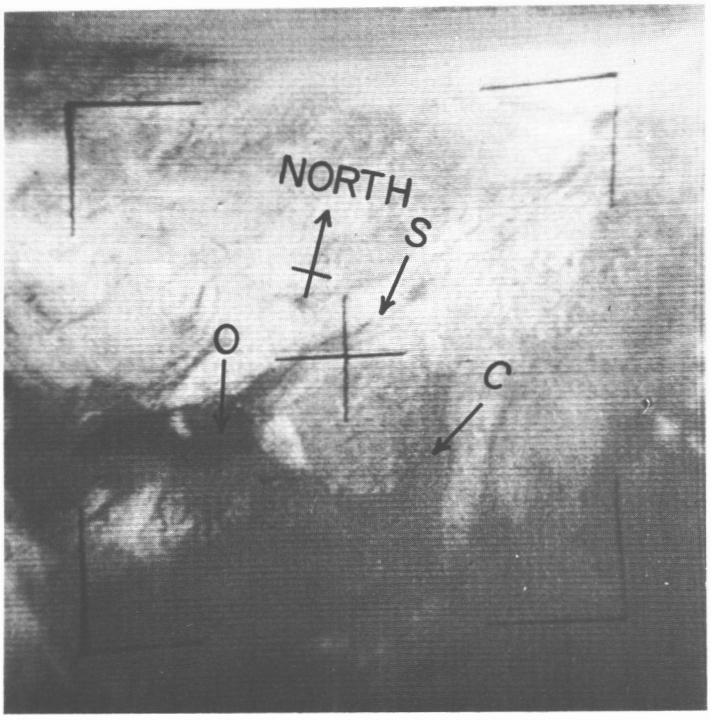

FIGURE 5.—Spring. Snow cover on trees of the mountains. Champlain Valley (C) clear, St. Lawrence valley (S) covered. 1755 GMT, April 5, 1962, TIROS IV, orbital pass 804, C1 D34.

to the arbitrary classification by the author [2] of white. At the same time, snow covers of several feet scarcely change the overall reflectance of the Adirondacks. In New England, snow covers from several inches upward make the Connecticut River Valley barely discernible from its neighboring hills. These conditions are illustrated in figure 4.

Spring: Although a snow cover usually exists in the mountains while the valleys are clear of snow, the Adirondacks appear darker than the valleys. Only upon rare occasions, which usually occur in the spring or fall, do the mountains appear lighter than the valleys. This occurs when wet snow covers the trees. At these times rain falls in the valleys. This condition is illustrated in figure 5. Similar accumulations of dry snow on the trees is rare because of frequent winds. Elevations above 1 km. in winter are usually rimed, and one would expect that these areas would show in the photography. However, they have not been identified as such, apparently because the areas are too small.

These observations show the seasonal variations in picture tone. At times the variations are large enough to completely reverse their normal relative values, thus causing confusion to those who must interpret clouds and cloud amounts against these backgrounds. Similar details for other parts of the world are necessary to obtain maximum use from the satellite pictures.

REFERENCES

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2. J. H. Conover, "Cloud Interpretation from Satellite Altitudes," *Research Note* No. 81, Supplement 1, AFCRL–62–630, Air Force Cambridge Research Center, Bedford, Mass., 1963.
3. J. F. Cronin, "Terrestrial Features of the United States as Viewed by TIROS," *Scientific Report* No. 2 on Contract AF19(628)–2471, ARACON Geophysics Co., Concord, Mass., July 1963, 35 pp. (AFCRL–63–664).
4. A. Morrison and B. J. Bird, "Photography of Earth from Space and Its Non-Meteorological Applications," *Proceedings of 3d Symposium on Remote Sensing of Environment*, University of Michigan, Ann Arbor, Mich., 1964.

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